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Normative static grip strength of population of Turkey, effects of various factors and a comparison with international norms

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ABSTRACT

Normative data are of importance in ergonomics and clinical settings. Applying normative data internationally is questionable. To this end, this study aimed to establish gender- and age-specific reference values for static (isometric) hand grip strength of normal population of Turkey with special regard to occupational demand, and compare them with the international norms. The secondary aims were to investigate the effects of gender, age-group, weight-group, job-group, hand and several anthropometric variables on static grip strength. A sample of 211 (128 male and 83 female) volunteers aged between 18 and 69 with various occupations participated in the study. Grip strength data were collected using a Jamar dynamometer with standard testing position, protocol and instructions. The mean and std deviation of maximum voluntary static grip strength values (in N) for dominant and non-dominant hands respectively were 455.2 ± 73.6 and 441.5 ± 72.6 for males, and 258 ± 46.1 and 246.2 ± 49.1 for females. The mean female strength was about 57% of the mean male strength value for both dominant and non-dominant hands. There was a curvilinear relationship of grip strength to age, significant differences between genders, hands, and some age-groups, and a correlation to height, body-mass, BMI and hand dimensions depending on the gender. The comparisons with the norms of other world populations indicate that there are cross-national grip strength variations among some nations but not all.

1. Introduction

Population norms are developed to determine the capacity of the population and reference values. The developed norms are then used to design for health, safety, comfort and productivity of workforce and consumers and also for clinical purposes. Of these, grip strength norms are often required for safe manual work, tool and product design requiring grip strength; and also for pre-employment screening, work hardening and job-return following a post injury treatment. If the strength limits of the workforce or users are repetitively exceeded, fatigue and eventually injuries may occur (e.g.; Armstrong et al., 1987; Putz-Anderson, 1988; Kilbom, 1994; Eksioglu, 2004, 2006, 2011; Potvin, 2012).

A number of studies reported in the literature identify gender, age, height, weight, body mass index (BMI), and occupation as predictors for grip strength (e.g.; Bechtol, 1954; Schmidt and Toews, 1970; Agnew and Maas, 1982; Fraser and Benten, 1983; Mathiowetz et al., 1985; Hinson and Gench, 1989; Balogun et al., 1991; Crosby and Wehbe, 1994; Harth and Vetter, 1994; Josty et al., 1997; Fraser et al., 1999; Xiao et al., 2005; Bohannon et al., 2006; Anakwe et al., 2007; Wu et al., 2009; Werle et al., 2009). Several of these studies are described in more detail below.

Mathiowetz et al. (1985) studied grip and pinch strengths of 310 male and 328 female (20–94 years) from Milwaukee of USA. They obtained the highest grip strength at age group of 25–39.

The study by Balogun et al. (1991) with 960 volunteers (480 males and 480 females; 7–84 years) from Nigeria reported that static grip strength is positively related to both body weight and height at all ages, BMI, and age up to the third decade of life, and thereafter grip strength is inversely related to age.

Crosby and Wehbe (1994) studied 214 participants and found that height, weight, gender, hand dominance and hobby demands were predictive of grip strength.

Josty et al. (1997) studied 104 participants' grip and pinch strengths in non-manual, light manual and heavy manual workers using a Jamar dynamometer and a pinch measuring device. Heavy manual workers had the strongest grips with the least difference between sides. Office workers had the weakest grips and the

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greatest difference between sides. Light manual workers were between these two groups.

A study by Xiao et al. (2005) studied isometric muscle strengths of a sample of 193 mainland Chinese (146 males and 47 females) from the city of Ningbo. The study reported that male grip strength was about 50% higher than female grip strength (50.6% for left grip, 52.3% for right grip). A 2.5 cm grip span was used for both genders. In addition, industrial workers and students had higher mean strengths than administrators for males, and industrial workers had higher mean strengths than students. They also found significant correlations between grip strength and a number of anthropometric variables including weight, height (male only) BMI (exc. male right grip strength).

Kamarul et al. (2006) studied the grip strength of adult Malaysian population (412 participants, 200 women and 212 men, 18–65 years) and concluded that hand grip strength is significantly correlated with hand dominance, gender, occupation, height and weight, but not BMI. The study also reported that the mean hand grip strengths of Malaysian participants were significantly weaker than those reported for American or European populations and thus data derived from western populations cannot be applied to a comparable Malaysian population.

Bohannon et al. (2006) performed a meta-analysis by consolidating 12 previous multinational data (USA, Canada, UK, Australia, Sweden; 3317 participants) and presented age-, gender- and side specific reference values for hand grip strength. They reported that grip strength differs for males and females, grip strength differs between left and right sides and grip strength changes with age.

Anakwe et al. (2007) studied static grip strength of 250 participants (172 males and 78 females, 18–83 years) from South East Scotland and found that grip strength was greatest for the 35 to 44 year-old group for both genders and grip strength was consistently greater for men than women. Manual workers had greater mean grip strengths than non-manual workers, and forearm circumference was positively correlated with male grip strength. The study used second setting of Jamar hydraulic handgrip dynamometer. Male participants were composed of manual and nonmanual employees, and female participants of nonmanual employees only. For both genders, dominant hand grip strength was greater than the non-dominant hand.

A study by Werle et al. (2009) with 1023 Swiss participants (both genders of 18–96 years) revealed a curvilinear relationship of grip and pinch strength to age, a correlation to height, weight and significant differences between occupational groups.

The findings from the previous studies can be summarized as follows: (i) males have a greater grip strength than females, (ii) grip strength has a curvilinear relationship to age which results in an increase in grip strength with increasing age to reach a peak at 30–45 years, and then a decrease with increasing age, (iii) manual workers have greater mean grip strengths than non-manual workers (for the majority of the studies), (iv) dominant hand has greater grip strength capability than nondominant hand with right hand dominant participants; however, for left hand dominat participants the difference is less and even not significant, and (v) there is a positive correlation between grip strength, weight, height and BMI in healthy participants for a significant number of cases.

In addition, there are a number of studies that found cross-national and ethnic differences in grip strength (e.g.; Guthrie et al. cited in Chapanis, 1975; Desrosiers et al., 1995; Butler, 1997; Kothiyal and Tettey, 2000; Kamarul et al., 2006; Andersen-Ranberg et al., 2009; Wu et al., 2009; Werle et al., 2009; Araujo et al., 2010). According to Andersen-Ranberg et al. (2009), gene–environment (geographical region) interactions may explain country-specific differences. However, from the examination of a sample of available static grip strength studies (Table 1), it is not clear whether the cross-national differences are attributable solely to geographical region, racial difference, or other factors.

It is suggested by a number of studies that when designing work or product for strength, it is most appropriate to use normative data that have been developed using a population that closely matches the workforce or users being assessed. For comparisons, factors such as the appropriateness of the norm group (e.g., gender, age-group, job-group, anthropometry, geographical region) must also be considered (e.g., Innes, 1999; Bohannon et al., 2006; Andersen-Ranberg et al., 2009). Indeed, the most common grouping is based on country of residence (Innes, 1999).

Due to the non-existing universal strength norms yet, and the fore-mentioned potential cross-national or geographical variations, grip strength norms should be developed for various nationalities living in the same or different geographical regions. Another concern is to investigate whether the effects of various factors on grip strength for various populations are similar or not.

This study is the first attempt to establish strength norms of the normal population of Turkey. Therefore, the main objectives of this study were to:

(i) estimate the maximum voluntary static grip strength (GS) distribution of normal population of Turkey specific to gender, age-group, job-group and hand;
(ii) investigate the effects of gender, age-group, job-group, hand and body mass-group on GS for the population of Turkey.

The secondary objectives of the study were to:

(iii) investigate the strength of linear association between grip strength and a number of anthropometric characteristics (age, height, body mass, body mass index, hand length, hand breadth, and wrist circumference); and
(iv) compare the grip strength data of the population of Turkey with the GS norms of the population of a number of other countries.

2. Methods

2.1. Sampling

All the participants were recruited from the major metropolitan city of Istanbul and its surrounding areas. It was assumed that Istanbul approximately represents the general population of Turkey since the population of the city is composed of people whose birth places and family roots are from all the seven geographical regions of Turkey. The sampling was made so that all seven regions and most ethnic groups of Turkey are represented in the sample. The stratified random sampling method was used dividing the population of Turkey into strata: age-group, job-group and the geographical-region. If a participant's both birth place and family root were from the same region then the participant was considered from that region of Turkey.

The sample represented a wide variety of occupational and socio-economic backgrounds (e.g.; secretary, waiter, postman, housewife, baker, driver, factory worker, tailor, carpenter, mechanic, student, engineer, inspector, accountant and so on), which were classified into two main groups, namely, manual employees (ME –males only), non-manual employees (NME). NME is also divided into two sub groups: non-students (ns-NME) and students (s-NME). This sub-grouping of NME was made so that direct comparisons with the other population studies that included such grouping would be possible. The sample was also grouped into 10-year age bands as follows: (18–29), (30–39), (40–49), (50–59) and (≥60) (the last age-group included ns-NME only). Based on